Land Supply, House Price Capitalization, and Local Spending on Schools

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Abstract

Many researchers have noted that house prices reflect the capitalized value of local public services and amenities on house prices, but few empirical papers link the extent of house price capitalization to local spending decisions. In this paper we show that the causality indeed runs in both directions; in particular, local spending is higher in places with a greater degree of capitalization. To begin we make a simple observation; the degree to which house prices capitalize local amenities can vary substantially depending on the supply of land for new housing. In response to demand shocks, locations with more available land will have a larger adjustment in quantity, but a smaller adjustment in price and vice versa. We examine these predictions using a unique data set for Massachusetts that includes a measure of available land that varies by community and takes advantage of a property tax limit (Proposition 2½) that provides instruments for local changes in spending. Indeed, we find that fiscal variables and amenities are capitalized to a much greater extent in cities and towns with little available land, and confirm that these locations have a lower elasticity of land supply. We then show that localities with little available land spend more on schools, even after controlling for other factors that might affect demand for education. These results provide an alternative explanation for why suburban locations with little available land have relatively high spending on local schools.

1 Introduction and Background

Following the publication of Oates' pioneering paper in 1969, a large theoretical and empirical literature has addressed house price capitalization. For the most part, the literature agrees that long-run house values should fully reflect cross-sectional differences in the present discounted value of future tax burdens or benefits, after controlling for housing characteristics. Such an approach depends on demand factors alone, and assumes that the supply of land is inelastic and similar across locations.[1] Recent econometric studies (among others Yinger et al. 1988, Stull and Stull 1991, Smith and Huang 1995, Man and Bell 1996, Palmon and Smith 1998a and 1998b, Hilber 1998, Sinai 1998, and Black 1999) strongly confirm the existence of capitalization of local public goods such as schools and environmental amenities.[2]

A few studies examine the possibility of variations in the supply elasticity among different locations (e.g., Malpezzi 1996 and Dreiman and Follain 2001) or the effect of differential land supply elasticity on the extent of capitalization (e.g., Bruce and Holtz-Eakin 1999). However, to our knowledge, so far no study examined empirically and in a well identified setting whether the land supply elasticity affects the extent to which local amenities and fiscal variables are capitalized into house values, that is, whether the extent of capitalization differs by location.

In this paper we make two points. First, we suggest that house price capitalization estimates from cross-sectional analyses cannot be easily interpreted as a household's willingness to pay for amenities or local services when land for new development is readily available. We posit that capitalization of fiscal variables and amenities should vary across communities, with a greater degree of capitalization in communities with a more inelastic supply of residential land. This result is quite intuitive. As long as land supply is not perfectly inelastic (or perfectly elastic) and communities are not perfect substitutes, both price and quantity will adjust in response to demand shocks. However, price adjustment should be larger (and quantity adjustment smaller) in places with less available land.

[1] A few theoretical papers have argued the opposite point; that the supply of land is perfectly elastic, and thus the degree of capitalization should be quite limited. For example, Edel and Sclar (1974) and Hamilton (1976b) suggest pressure from developers will successfully pressure communities to expand any type of housing that earns economic rents. Hence, capitalization is a disequilibrium phenomenon that will disappear in the long run.

[2] Two exceptions are McMillan and Carlson (1977), who use a sample of small Wisconsin towns and show that amenities are not capitalized in a hedonic regression and Bui and Mayer (2000) who show that certain environmental emissions are not capitalized using a repeat sales methodology.

Second, we suggest that the level of local spending on public goods should depend on the extent to which fiscal variables and amenities are capitalized into property values. This proposition is based on previous theoretical work by other authors. Wildasin (1979) and Sonstelie and Portney (1980) point out that in a frictionless world homeowners have an incentive to vote for the local public good level that maximizes the values of their houses. They then pocket the proceeds and move to a community where public spending is ideal from a pure consumption point of view. Brueckner and Joo (1991) then demonstrate that in a world with imperfectly mobile voters and in the presence of house value capitalization the voter's ideal spending level for durable local public goods reflects a blend of his or her own preferences and those of the eventual buyer of the house. This behavior may explain, for example, why the median voter supports additional school spending even though he or she has no children at school.

Our empirical findings, which confirm the effect of land availability on the extent of capitalization and on school spending, have implications for theoretical and empirical studies in a variety of areas. For example, urban quality-of-life and environmental comparisons use implicitly generated prices of local amenities by assuming uniform capitalization of interurban amenity differences into local land rents and wage rates (e.g., Blomquist et al. 1988, Gyourko and Tracy 1991).[3] Other cross-sectional studies estimate the marginal value of reducing air pollution by assuming uniform house price capitalization (see e.g., the meta-analysis by Smith and Huang 1995). However, the extent of land value capitalization of amenities may be significantly higher in metropolitan areas with a limited supply of available land or regulations that deter new development, potentially distorting the reported quality of life rankings and the benefits of improving air quality.[4]

The same issues apply to the capitalization of fiscal variables into property values. In recent policy debates it is often argued that public school spending increases the attractiveness of their community to the marginal homebuyer and thus increases housing values (e.g., Haurin and Brasington 1996, Black 1999 and Dee 2000). However, a strict link between school expenditures—or more precisely school quality improvements—and house prices only exists if land supply is equally inelastic in all observed locations. While Black (1999) looks only at

[3] See Gyourko, Kahn, and Tracy (1999) for an survey of the literature about quality of life and environmental quality in urban areas.

[4] The size of the distortion may depend on geographic units of observations. Gyourko and Tracy (1991) chose the central city of the metropolitan area as their observation unit and may thus minimize the size of the distortion.

houses very close to attendance district boundaries where land supply might indeed be equally and completely inelastic, Haurin and Brasington (1996) and Dee (2000) present estimates based on much less disaggregated data, which might be biased if land supply, and thus the true extent of capitalization, is correlated with other factors such as the median income of a community.

Many public policies are potentially affected by the link between government subsidies and house price capitalization. Consider intergovernmental transfers from federal or state governments to communities based on the poor school quality or the number of poor residents. Many authors have argued that such location-based aid (as opposed to grants to poor individuals) can have adverse consequences since poor residents are typically renters who will be forced to pay higher rents if the transfers are capitalized into higher house prices (e.g., Hamilton 1976a and Wyckoff 1995).[5] Our results suggest that such adverse redistributional effects should be concentrated mainly in locations with little available land. Variation in the extent of capitalization may also lead to differences in homeowner benefits from the mortgage interest deduction and have implications of other types of fundamental tax reform in the US.[6]

Finally, some authors argue that the capitalization of benefits of durable local public goods into property values can induce local governments to behave efficiently (e.g., Edelson 1976 and Sonstely and Portney 1978, and Fischel 2001) or that land value capitalization provides a mechanism to induce present generations to internalize the well-being of future generations (e.g., Oates and Schwab 1988 and 1996, Glaeser 1996, and Conley and Rangel 2001). Fischel (2001) describes homeowners as "homevoters" whose voting and other local political activities are guided by their concerns about home values. Fischel's homevoter model implies "…that local property taxes are benefit taxes, that locally funded schools are more efficient than state-funded systems, and that home-conscious "NIMBYs" [folks who cry "not in my backyard"] forestall an environmentally destructive "race to the bottom" in tax base competition." However, such

[5] Hamilton (1976a) first makes the link between capitalization and inequality. He argues that if differential fiscal surpluses are fully capitalized into demand curves for property, there can be no inequality in a static world. Wyckoff (1995) suggests that voter movement will cause equalizing intergovernmental aid (such as state education aid) to be capitalized into housing prices. Assuming a fixed housing supply, he shows theoretically that in many cases, intergovernmental grants have no net effect on the welfare of the poor citizens (i.e. the welfare effect of intergovernmental aid on poor voters is completely offset by higher housing costs), and in a few cases, the grants may even make them worse off. However, if land supply is not completely inelastic fiscal differences do not have to be fully capitalized into housing values and therefore the conclusions of Wyckoff need not hold.

[6] For a discussion of the effect of mortgage interest deductions on housing prices see Capozza, Green, and Hendershott (1996).

normative implications depend critically on the extent of capitalization, and thereby, as our empirical results suggest, on the availability of land in a specific location.

To establish the point that the land supply elasticity influences the extent of capitalization, Section 2.1 explores the conditions that affect the influence of the land supply elasticity on the extent of capitalization. We demonstrate that an exogenous local demand shock—such as a 'fiscal shock'[7]— is capitalized into house values to a greater extent in communities with less elastic housing supply so long as households are imperfectly mobile or the communities' share of metropolitan population is not marginal. In Section 2.2 we argue that the introduction of a property tax limit can be interpreted as just such a 'fiscal shock'. Bradbury, Mayer, and Case (2001—referred to as BMC, below) show that constrained communities who cannot choose their optimal level of local public services are able to realize gains in property values to the degree that they increase spending despite the limitation. We show that this capitalization should be greater in communities with a relatively inelastic land supply. Section 2.3 demonstrates that local land scarcity should reduce local public spending.

We examine these theoretical predictions in Section 3 using data for the Commonwealth of Massachusetts and building on the empirical framework used in BMC. This procedure uses exogenous variation from a property tax limit—Proposition 2½—to help predict spending levels across communities and looks at how house prices respond to variations in spending using instruments drawn from the tax limit. Consistent with theory, our results suggest that fiscal differentials and amenities are capitalized into house values to a much smaller extent in locations with greater land availability, as measured by the amount of undeveloped land in each city and town based on aerial photos. In addition, we confirm that locations with more undeveloped land have a greater land supply elasticity. Finally, we demonstrate that localities with little available land spend more on schools, even after controlling for other factors that might affect demand for education. Some of this increased spending comes from communities that are at their state-mandated property tax levy limits, but that choose to pass an override. While land availability has little effect on the probability that a town has reached its levy limit, voters in communities with little available land pass larger overrides. We conclude in section 4 with a brief discussion of policy implications.

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[7] Examples of such fiscal shocks are unexpected changes of federal grants towards cities or fiscal distortions induced by the introduction of property tax limits such as Proposition 2½ in Massachusetts.

2 Theoretical Framework

In the following analysis we argue that the extent of capitalization of fiscal variables and amenities should be particularly high in places where residential land supply is relatively inelastic because (almost) all land is already zoned for residential purposes—typically urban and suburban communities.[8] In rural areas and locations at the edge of cities, where residential land supply is typically quite elastic, exogenous improvements in local attractiveness lead to relatively minor effects on local residential land values, as open farmland is converted into residential land. In part, this argument assumes that land can be freely converted into residential use. Here we follow the findings of the "endogenous zoning literature".[9] For example, the empirical estimates of Pogodzinski and Sass (1994) strongly indicate that after controlling for selection bias, land-use regulations appear to "follow the market".

A second important assumption is that some aspects of current spending affect the utility level of future residents. This assumption would apply if some portion of current spending is on durable goods that benefit future residents, or if current spending decisions represent a signal or commitment to future spending. A few studies recognize that the extent of capitalization of future benefits of durable local public goods affects the spending level (e.g., Sprunger and Wilson 1998 and Hoyt 1999). Sprunger and Wilson (1998) note that in the absence of perfect labor mobility or under uncertainty about the future benefits of durable local public goods, these benefits may be overcapitalized or undercapitalized. They follow that there is underinvestment in some local public goods, but overinvestment in others. Hoyt (1999) points out that the lack of capitalization of inefficiently high taxes reduces the incentives of residents to limit government inefficiency. In the case of Massachusetts under Proposition 2½, increases in the levy (spending) limit are permanent, so if voters choose to increase the spending limit in one year, they are choosing to increase that limit in all future years as well.

8 For example Yinger (1982) points out that the finite size of urban areas makes land a scarce resource. Fischel (1990) points to a number of political factors that explain why communities pass restrictive zoning measures that move beyond just solving demand externalities and effectively limit supply.

9 For a summary of the "endogenous zoning literature" see Pogodzinski and Sass (1994). The literature on "economics of zoning" is founded on Mills and Oates (1975). For a general review of the literature see Fischel (1990) and Pogodzinski and Sass (1991).

2.1 General Predictions of How Land Supply Elasticity Affects Capitalization

In a model with a single market and a fixed number of (immobile) households it is quite intuitive that both price and quantity will adjust in response to demand shocks and that the price adjustment is larger (and quantity adjustment smaller) if land supply is inelastic. However, if households are mobile and can relocate between jurisdictions the same result is less obvious.

To examine whether the land supply elasticity influences the extent of capitalization even in a world with perfectly mobile households, we develop a model of two communities (or one specific community and the rest of the metropolis) that differ in their land supply elasticity. The model consists of N residents who are perfectly mobile and have identical incomes and tastes. Residents in both communities choose housing quantity to maximize utility, taking the level of public service, and the property tax rate as given. Equilibrium is achieved if households have equal utility in both communities. The model builds upon the seminal work of Epple and Zelenitz (1981) and is presented in detail in Appendix A.

The comparative statics of the model equilibrium give us some important insights. In the limit, if households are perfectly mobile and individual communities are very small relative to the metropolitan area, we show that the supply elasticity has little effect on housing values in a community. However, if either assumption is relaxed, we obtain the result that the extent of capitalization is decreasing in the supply elasticity.

First consider the assumption of community size. If residents truly consider all locations within a MSA to be equally viable, then individual communities might be considered small relative to the entire MSA. However, residents typically focus on some neighboring communities close to their working place. Thus, the share of the observed community compared to the "relevant" rest of the metropolis is typically quite large.

Furthermore, the model assumption of perfect mobility is quite unrealistic. In fact, relocation is typically very costly. Moving costs for homeowners are often as high as 10 percent of the value of a house, including the cost of the broker fee, carrying costs of the property for sale and direct moving expenses. If households are imperfectly mobile, theory suggests that the housing supply elasticity affects the extent of capitalization and that relative community size has a minor effect. Hence, to the extent that households are not perfectly mobile and to the extent that the relative population sizes of communities that are affected by an exogenous demand shock are not infinitesimal we therefore expect that capitalization rates differ significantly between communities with elastic and inelastic land supply.

2.2 Property Tax Limits as Fiscal Shocks

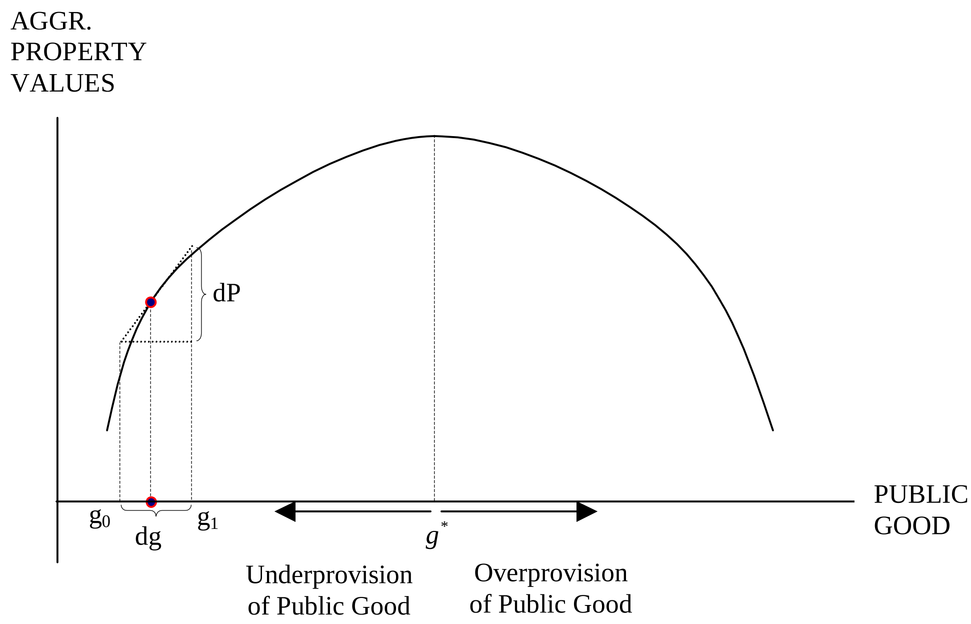
A. General Considerations

Brueckner (1982) notes that if local governments provide local public goods in a property-value-maximizing fashion, they will choose a spending level such that the marginal benefit of an extra dollar of spending will be exactly offset by the marginal cost of the property taxes needed to finance that spending. Mathematically, this can be expressed as

$$\frac{\partial P}{\partial g_k} = \frac{1}{\theta}\left(\sum_{i=1}^{n} MRS_{g_k,x} - MC_{g_k}\right) = 0\,, \tag{1}$$

where P is the aggregated property value in the community, g_k is the level of local public good k, θ is the discount rate, $MRS_{g_k,x}$ are the marginal rates of substitution between the public good g_k and the numeraire x (for all residents i=1,...,n), and MC_{g_k} is the marginal cost to provide g_k. Brueckner (1982) concludes that if $\partial P / \partial g_k > 0$ the local public good g_k is underprovided, while if $\partial P / \partial g_k < 0$ the good g_k is overprovided relative to the property-value-maximizing level. Thus, a finding that house price changes respond positively (negatively) to spending changes implies that an increase (a reduction) in spending raises the relative attractiveness of a community. Brueckner's (1982) argument is illustrated in Figure 1 for the simplified case, where aggregate property values are a simple single-peaked function of a single local public good g. A public good level left of the peak signifies underprovision, while a level right of the peak signifies overprovision.

Figure 1: Public Goods and Aggregated Property Values



We subsequently use these considerations to analyze the effect of a tax reform that limits property taxes. Such property tax limits exist in many places around the US due to statewide limits that were passed by voters in the 1970s and 1980s.[10] Many property tax limits were passed based on the perception that local officials had a tendency to spend more on public services than the residents wanted. According to this logic and according to Brueckner's considerations, the existence of a property tax limit will increase the utility of homeowners[11] if communities were indeed overproviding the public good ($\partial P / \partial g_k < 0$). However, if the limit restricts the local government from increasing spending to the optimal level, that is, $\partial P / \partial g_k > 0$, the utility of homeowners is decreased in restricted communities. Such a fiscal distortion associated with the introduction of a property tax limit could be interpreted as a "negative lump sum payment" for the homeowners living in communities that are constrained to spend "too little" on local services. Restricted communities may realize gains in property values (that is, they may reduce the extent of the negative lump sum payment induced by the property tax limit) to the degree that they are able to overcome the limits.

[10] California, Michigan, and Massachusetts are examples of states that imposed tax limitations on local communities ability to raise taxes to finance local services.

[11] Brueckner (1982, 315) argues that the same result holds for rental and owner-occupied housing units because in equilibrium a resident must be indifferent between owning and renting his or her housing unit.

Brueckner's (1982) efficiency statement has been criticized on a number of dimensions. First, Yinger (1985) argues from a theoretical point of view that property taxes apply to both capital (the value of the housing structure) and land. Thereby the existence of property taxes drives a wedge between the first order conditions that govern the spending choice of communities and housing consumption of individuals. As a result, local spending choices are only second best. The second critique derives from the fact that in a world with heterogeneity the median voter's preferences, which determine spending, differ from the marginal homebuyers.[12] Finally, voters may not have full control over spending decisions.

Empirically, BMC show that the tax limit in Massachusetts, Proposition 2½, significantly constrained local spending in some communities and that these constrained communities realized gains in property values to the extent that they were able to increase spending despite the limitation. As mentioned above, such a finding may not imply underprovision from an efficiency point of view. However, such a finding implies that increases in spending raise the relative attractiveness of a community in the eye of the marginal homebuyer. This is because the marginal homebuyer judges the average community to be spending too little and prefers communities that increase spending.

B. The Case of Proposition 2½ in Massachusetts and Previous Findings By Bradbury, Mayer, and Case (2001)

Below, we consider the tax reform "Proposition 2½" in Massachusetts as a good setting to test our main propositions. Proposition 2½ was passed in November 1980. It placed important limits on local municipal spending: 1) effective property tax rates were capped at 2.5 percent and 2) nominal annual growth in property tax revenues was limited to 2.5 percent, unless residents passed a referendum (an override) allowing a greater increase. The limits imposed by Proposition 2½ applied equally to each city and town. However, variations in local economic and fiscal conditions at the time of its passage have led the measure to have very different impact on individual communities in Massachusetts (see BMC for a detailed description of the specific effects of Proposition 2½).

After the first few years when Proposition 2½ mandated actual revenue reductions, the tax limit had a limited effect on local budgets for a variety of reasons. First, the state government

[12] See Ross and Yinger (2000) for a summary of the literature that considers both a housing market and the market

considerably increased general purpose aid to municipalities to help them avoid possible budget shortfalls. Second, school expenditures declined because of a demographically-driven decline in the number of school-aged children. Third, the state-wide real estate boom in the mid 1980s meant that the new growth provisions added considerably to towns' levy limits. Fourth, inflation was relatively low. As a result of these factors, many communities raised taxes at a slower pace than allowed under Proposition 2½.

In the late 1980s, however, economic conditions and demographic trends changed dramatically. By 1990, 224 out of 351 towns were at their levy limit. Between 1990 to 1994—the time period of our econometric analysis—Massachusetts municipalities faced significant fiscal stress because of a 30 percent cut in real state aid and a demographically driven increase in school enrollments. While it was still possible for towns to avoid the levy limit by imposing higher local user fees, such non-property tax revenues were very limited and highly unattractive for its residents due to the imposed income tax burden. Hence, the only remaining possibility for residents was to pass a referendum—an override—allowing a greater increase. An override raises the levy limit for a specific year, and that increase becomes a permanent part of the levy limit. However, an override can never raise the effective property tax rate above 2.5 percent.[13]

BMC use this setting to explore the impact of spending changes on housing values, taking advantage of the tax reform to provide instruments that are correlated with local changes in spending, but are unrelated to property values, and avoiding many of the empirical problems that Palmon and Smith (1998b) argue have plagued past capitalization studies.[14] The study has three principal findings: 1) Proposition 2½ significantly constrained local spending in some communities, with most of its impact on school spending, 2) constrained communities realized gains in property values to the degree that they were able to increase school spending despite the limitation, and 3) changes in non-school spending had little impact on property values. By constraining school spending, Proposition 2½ may have added a scarcity premium for housing in

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for local public services in a setting with heterogeneous households.

[13] In a few cases, communities could choose to pass a temporary exclusion as opposed to an override. An exclusion is a temporary increase in a community's levy limit to pay for an "excluded" capital expenditure. Exclusions can temporarily raise the property tax rate above 2.5 percent.

[14] Virtually all past empirical capitalization studies are based on Lancaster's (1966) hedonic price index approach that treats a commodity as a bundle of characteristics. Utilizing the market parallel to Lancaster's approach, the price of a house can be described as a function of the valuation of the various characteristics of the house, such as site, structure, neighborhood, public services and taxes. However, this empirical procedure has a number of important problems that can lead to significant biases when it is implemented. Palmon and Smith (1998b) place the empirical problems into five broad categories: (1) underidentification, (2) potential correlation between

localities that were able to increase school spending at a time of great fiscal stress. The authors interpret their results as indicating that the marginal homebuyer may place a higher value on school spending than the median voter, possibly because typical homebuyers may have been more likely to have children in public schools.

Overall, the empirical findings by BMC strongly suggest that Proposition 2½ caused many communities to spend "too little" on local public education and that communities were able to realize gains in property values to the extent that they were able to increase spending in spite of the limitation.[15] These results imply that over this time period, the spending levels of communities in Massachusetts lie to the left of the peak of the curve in Figure 1, so that $\partial P / \partial g > 0$. That is, to the extent that towns were able to increase spending *dg* despite the limitation, they could realize gains in property values *dP*.

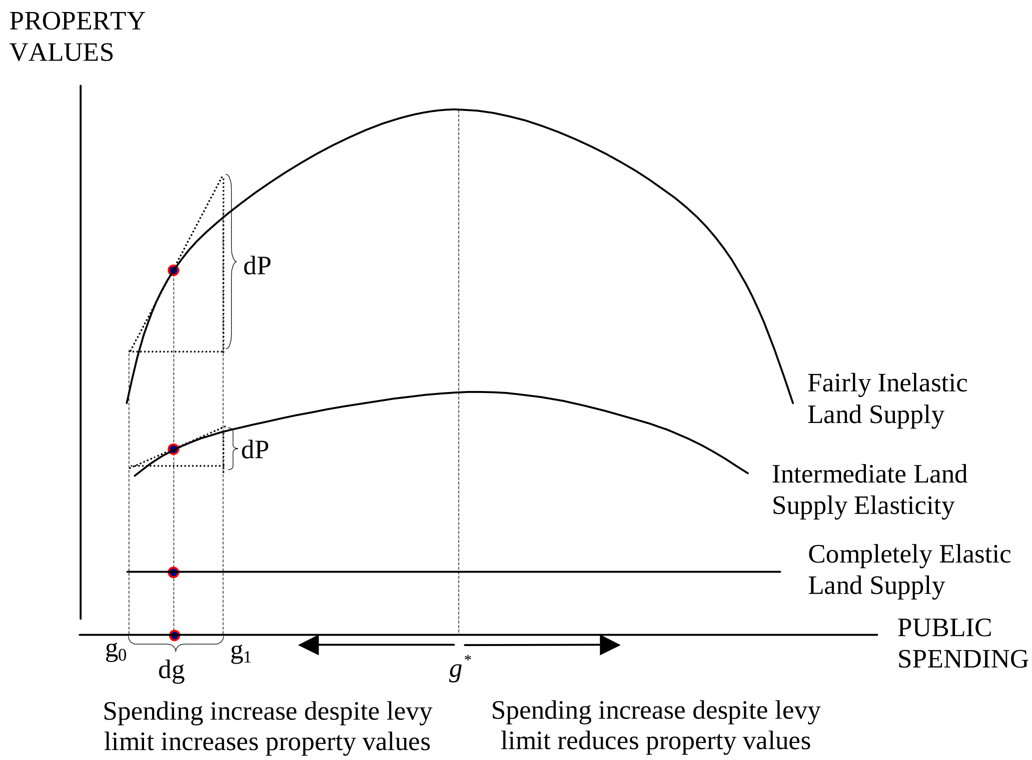
The econometric framework of BMC can also be used to test our main hypothesis that the capitalization of fiscal variables and amenities varies across communities. Empirically, communities that can increase spending despite Proposition 2½ should realize stronger gains in property values if their land supply curve is inelastic rather than elastic. This effect is illustrated in Figure 2. The figure shows the effect of a fiscal shock such as a property tax limit on property values for various degrees of land supply elasticity (completely elastic, intermediate elasticity, fairly inelastic). As proposed in (A17) in Appendix A and proved in Appendix B, the capitalized impact of an exogenous change in the spending level on public services depends on the land supply elasticity, which is indicated by the steepness of the three curves.[16]

included and excluded variables, (3) measurement error in the variables, (4) simultaneity bias, and (5) potential misspecification.

[15] This empirical evidence is somewhat puzzling given the fact that a majority of Massachusetts citizens voted in favor of Proposition 2 ½ in November 1980. Brueckner (1982) notes that "voters may have subscribed to the to the common 'tax revolt' notion that reduced government waste would allow maintenance of public consumption levels in the face of smaller budgets". In this context the passage of Proposition 2 ½ is not inconsistent with the empirical findings of Brueckner (1982) or BMC.

[16] The price level of the three curves can be considered as arbitrary. However, rural communities that have elastic land supply typically also have few positive amenities and consist mostly of inexpensive farmland while suburban and urban communities with inelastic supply of land typically have more positive amenities and have a much greater extent of more expensive residential land.

Figure 2: Land Supply Elasticity and Capitalization



Consider a specific community. The tax limitation prevents the local government from choosing the property value maximizing public good level g^*. Instead, the community that is constrained by Proposition 2½ can only provide g_0. The fiscal distortion induced by the property tax limit results in lower property values. If the community increases the public spending level despite the limitation to g_1 it realizes gains in property values. However, the change in property values for a given change in public services depends on the land supply elasticity. A community with inelastic land supply will have a greater increase in property values than a location with more elastic land supply. We examine this hypothesis in Section 3.

2.3 Capitalization and School Spending

The previous theoretical literature pointed out that in a frictionless world and in the presence of house value capitalization, voters take into account preferences of eventual buyers of their house (e.g., Wildasin 1979 and Sonstelie and Portney 1980). Hence, their ideal spending level for durable local public goods may not reflect their own preferences. Brueckner and Joo (1991) demonstrate that this result holds even in a world with imperfectly mobile voters. However, such arguments are based on the assumption of full capitalization. As Sprunger and Wilson (1998) note, future benefits of durable local public goods may be undercapitalized or overcapitalized into house values.[17] To the extent that these public goods are not fully capitalized and given that the spending level is to the left of the peaks of the curves in Figure 2, this may lead to underinvestment (left of the peak of the curves in Figure 1 and 2) because current homeowners have not enough incentives to take into account preferences of future residents (or future generations). Hoyt (1999) correctly points out that—in the case of overprovision (right side of the curve in Figure 1 and 2)—lack of capitalization may also reduce incentives of homeowners to limit government inefficiency. Correspondingly, we predict that land availability should affect the extent of house value capitalization and thereby public spending.

BMC suggest that Proposition 2½ caused many communities to spend "too little" on schools (left of the peak of the curves in Figure 1 and 2) and that communities were able to realize gains in property values to the extent that they were able to increase school spending in spite of the limitation.[18] Hence, we predict that communities with little available land, everything else equal, should spend more on schools and should be more likely to pass an override in order to increase (school) spending than communities with more available land. The intuition behind this prediction is quite straightforward. If additional spending on schools is fully capitalized into higher house values, certain (not completely immobile) households might be willing to vote in favor of the spending even though they have no children. This is because these households might sell their houses in the future (most likely to families with children), pocket the proceeds, and move to a community where the public spending is ideal from a pure consumption point of view. Now consider the other extreme case with perfectly elastic land supply and thereby no capitalization. Investments in durable school facilities will attract other households to the community. But because land supply is perfectly elastic this will not increase house values, rather, new farmland will be zoned as residential land. However, in this case households that have no children only have to pay additional taxes without getting any benefits. Hence, households that have no children—unless they have interdependent utility functions or are

[17] Several studies describe the factors that may lead to less than full capitalization or even "overcapitalization" (e.g., Sprunger and Wilson (1998), Hilber (1998), and Hoyt (1999). See Hilber (1998) for an overview and a discussion of the impact of these determinants on the extent of capitalization.

altruistic—will vote against additional spending.[19] We examine this prediction in the empirical work below.

3 Empirical Analysis

The theoretical considerations in the preceding section predict that land prices, and thus house prices, should change more strongly in response to an increase in public spending in areas with little available land than in areas with plenty of undeveloped land. Recognizing that increases in spending result in higher house prices, communities with little available land should spend more on schools and be more likely to pass an override in order to increase school spending. To test these hypotheses, we turn to data from Massachusetts and look at the impact of Proposition 2½ on property values. In doing so, we utilize the basic framework in BMC to explore empirically how capitalization rates vary with the amount of available land in a community.

We choose the 1990-1994 time period in Massachusetts for two reasons. First and foremost, we are able to estimate the impact of government policy on house values using a well-identified methodology. Identification is quite important given that fiscal variables, such as government grants and property taxes, are not chosen randomly, and may depend on local conditions, including house prices. Thus it is often difficult to estimate a basic capitalization equation, even before considering differences in the extent of capitalization across communities. BMC use community characteristics and measures of Proposition 2½ from the date of its original passage in 1980 as instruments for spending changes ten years later.

Second, and equally important, we have very detailed data on land availability in Massachusetts that allows us to directly measure the amount of available land in each community, rather than using proxies such as density or distance from the city center. After all, the theoretical prediction depends on potential new construction to mitigate changes in house prices in some communities. Density can depend on other factors such as the amount of commercial development and local zoning restrictions that might obscure our ability to link capitalization with land availability. Similarly, distance from the city center only proxies for land

[18] In contrast, increases in non-school spending had little impact on house prices. See the empirical section for potential explanations of this finding.

[19] We would also predict that, ceteris paribus, the less mobile these households are the more likely they are to oppose the additional spending. This is because the loss increases with the duration of the stay.

availability in a typical monocentric city without suburban sub-centers and with equal access to the city center from all directions. Neither of these assumptions holds for Boston, the major metropolitan area in our sample.

3.1 Empirical Specification

Our basic estimating equation for house prices is as follows:

$$\Delta P = \beta_0 + \beta_1(\text{local characteristics}) + \beta_2(\Delta\ \text{spending}) + \beta_3(\Delta\ \text{housing stock}) + \varepsilon\ . \qquad (2)$$

This equation is derived by differencing a standard hedonic equation. We examine changes in spending and house prices, rather than levels of those variables, to control for the possibility of omitted fixed effects that might be correlated with included independent variables and thus bias cross-sectional regressions. Recognizing the difficulty in measuring the quality of local services and schools, we include only spending on the right-hand side of the equation. Following Brueckner (1982), we interpret the coefficient on (change in) school spending as the net impact on house prices of spending another dollar on schools, holding constant the taxes necessary to pay for the additional spending.

Regressions for house price changes between 1990 and 1994 are estimated using two-stage least squares[20] and assume that changes in spending and new single-family home permits (Δ housing stock) are endogenous. Instruments include the amount of developable land in 1984 and lagged permits as instruments for change in quantity, and additional instruments for spending changes using variables from the time immediately surrounding 1980 when the tax limit was passed. One group of such instruments comes directly from Proposition 2½, while a second group of instruments add resource and cost factors that affect spending changes, including the growth in state aid from 1981 through 1984 to capture the state government's immediate response to Proposition 2½. We also report a second set of estimates that utilize additional instruments from the late 1980s that help identify changes in non-school spending, but are less clearly exogenous.[21]

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[20] We are utilizing White's (1980) heteroskedasticity-consistent estimator of the variance-covariance matrix and thus report robust standard errors.

[21] See BMC for a more detailed explanation of these instruments and possible issues relating to exogeneity for all of these regressions.

The estimating equation also contains a number of levels variables to account for possible changes over time in the capitalized value of selected town characteristics as a result of aggregate shocks.[22] For example, the aging of the baby boom and the associated echo baby boom has led to an increase in public school enrollments in Massachusetts since 1990. The resulting increase in the number of households with children in public schools has raised the demand for houses in towns with good quality schools. BMC show that the increase in demand for good schools led to higher house prices in communities with good test scores over the 1990-94 time period.

In examining differential capitalization, we divide the sample into two groups based on an indicator of land supply elasticity. Our most direct measure is the percentage of open and public (undeveloped) land in each community. This variable comes from a University of Massachusetts aerial survey of the entire Commonwealth of Massachusetts in 1984. All land is classified into 21 uses. We classify communities based on the percentage of open or undeveloped land, which includes farm land. In the initial regressions, we divide the sample into 2 equal-sized groups and compare the coefficients across these two groups. In separate regressions, we also divide the sample based on population density, but expect that this measure may perform more poorly than the more direct measure of the amount of undeveloped land.

In places with little available land, we expect that the restrictions imposed by Proposition 2½ will generate higher price changes, but smaller quantity changes relative to places with more available land. In other words, the coefficients on changes in spending (β_2), or on the other characteristics, in the capitalization equation should be larger in the group of communities with little available land. A second implication of the theory is that these locations should have a lower supply elasticity. To examine this second hypothesis, we specify a supply equation consistent with the demand equation (2):

$$(\Delta \text{ housing stock}) = \gamma_0 + \gamma_1(\Delta P) + \gamma_2(\text{lagged permits}) + \mu \,. \tag{3}$$

Equation (2) provides a large number of exogenous demand instruments to identify the supply elasticity. Locations with less available land should have a smaller land supply elasticity (γ_1) and, possibly, lower levels of new construction (γ_2). This second test provides important reinforcing evidence that the differences in capitalization identified in the price equation are due

[22] Using a similar data set, but an earlier time period, Case and Mayer (1996) find that the capitalized values of good schools, of proximity to Boston, and of other town attributes vary significantly over time.

to differences in the land supply elasticity as opposed to differences in "unobserved" community attributes that may be correlated with available land.

In assessing the results, notice that our empirical specification looks at changes in house prices over a 4-year period. To the extent that longer-run supply is more elastic than short-run supply, our empirical work might over-estimate the price effects and underestimate the quantity effects of a given fiscal change in towns with more available land. This will bias us against finding any effect of land availability on capitalization and supply elasticities.

Finally, we test our second main proposition that land supply—and thereby the extent of capitalization—affects local spending. First, we directly examine the impact of land availability on local public spending, whether or not communities are constrained by their levy limit. We estimate spending regressions for school spending as well as non-school spending and control for several local characteristics that might also affect local spending. In addition we include the land scarcity variable that proxies for land supply elasticity. The estimating equation is as follows:

$$\Delta\text{spending} = \delta_0 + \delta_1(\text{\% developed land}) + \delta_2(\text{local characteristics}) + \nu\,. \tag{4}$$

We then limit our sample to communities that are constrained by Proposition 2½ to see if communities with little available land are more likely to pass overrides that increase spending. The estimating equation can be expressed as follows:

$$\left(\sum \text{overrides} \middle| \text{at levy limit}\right) = \pi_0 + \pi_1(\text{\% developed land}) + \pi_2(\text{local characteristics}) + \varpi\,. \tag{5}$$

Finally, we confirm that the land availability does not affect the probability that a town is at its levy limit—even though the land availability affects the amount of overrides conditional on being at the levy limit. We estimate the following equation:

$$\Pr\left(\text{at levy limit}\right) = \rho_0 + \rho_1(\text{\% developed land}) + \rho_2(\text{local characteristics}) + \psi\,. \tag{6}$$

3.2 The Data

The analysis below includes a large number of community characteristics, school indicators, and fiscal variables. These variables are summarized in Table 1 in Appendix C. During the 1990-94 period, communities show substantial variation in many of these variables. For example, despite an average increase in school spending of 15 percent, individual towns had large positive and negative changes.

The house price indexes presented in this paper are obtained from Case, Shiller, and Weiss, Inc. and are estimated using a variation on the weighted repeat sales methodology first presented in Case and Shiller (1987).[23] Because the indexes involve repeat sales of the same property, they are not affected by the mix of properties sold in a given time period or differences in average housing quality across communities. The sample includes 208 of the 351 cities and towns. Communities were dropped from the sample because they had too few sales to generate reliable indexes. As such, this data limitation might lead us to underestimate the impact of supply elasticity on capitalization. Communities with the fewest transactions that are dropped from the sample are also small, often rural, communities that may have the most available land and thus exhibit the smallest degree of capitalization.

3.3 Results

A. Land Supply and Extent of Capitalization

To begin, we estimate equation (2), but split the sample into two parts based on the percentage of available developable land. The results—reported in Table 2—are strongly consistent with the theoretical predictions posited above. Our preferred specification is reported in columns (1a) and (1b). In all cases, coefficients in the house price equation in column (1a)—communities with little available developable land—are larger in absolute value than coefficients in the house price equation in column (1b)—locations with more available land. BMC report that changes in school spending are capitalized into house prices, but changes in non-school spending have little effect on house prices. Thus we focus on the coefficient on changes in school

[23] The method uses arithmetic weighting described by Shiller (1991) and is based on recorded sales prices of all properties that pass through the market more than once during the period. The Massachusetts file contains over

spending. This variable has a coefficient that is almost three times larger (0.32 versus 0.12) in towns with little available land. In fact, the coefficient for change in school spending is not statistically different from zero in column (1b), but is highly statistically significant in column (1a). We find smaller, but qualitatively similar results for the average test score. Given the growth of employment in the city of Boston, good commuting locations—communities in the Boston MSA and in the suburban ring—also became relatively more valuable in communities with little available land. A test of equality for all of the coefficients in columns (1a) and (1b) rejects the hypothesis with a p-value of 0.06.

The coefficients on other variables are also of interest. For example, price changes with respect to new supply are much larger in developed communities, where there is much less construction.

Columns (2a) and (2b) report the same regressions using a broader set of instruments from Proposition 2½. The results here are quite consistent with those in the first two columns in virtually all cases, although the difference in coefficients is slightly smaller in a couple of cases.

Table 3 reports the same regressions, except that we split the sample based on population density instead of available land. One advantage of this measure is that population density is reported in 1990, more contemporaneous to our sample period than land availability, which is only available in 1984. However, cross-sectional differences in commercial development and zoning policies could weaken the relationship between available supply and population density. Consistent with our theoretical considerations, the primary variables, change in school spending and average test scores, are larger in absolute value in dense than less dense locations. Nonetheless, these results are somewhat weaker than in the previous table.

Finally, we return to the quantity test described above. Here we find evidence in favor of the hypothesis that locations with more available land have a higher elasticity of land supply. That is consistent with our theoretical considerations, as it suggests that shocks to demand lead to greater new construction in locations with more available land in addition to the lower extent of capitalization that we found above.

The number of single-family home permits is the dependent variable in all supply equations. Columns (1a) and (1b) in Table 4 in Appendix C report land supply elasticities without using lagged supply as exogenous variable. The two columns show large differences

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135,000 pairs of sales drawn between 1982 and 1995. First, an aggregate index was calculated based on all recorded sale pairs. Next, indexes were calculated for individual jurisdictions.

between the two groups. The coefficient on change in house prices is quite small and not statistically significant in the more developed locations. The test of equality between the coefficients in columns (1a) and (1b) rejects with a p-value of 0.11. Columns (2a) and (2b) in Table 4 include lagged permits to control for other factors that might lead to new construction. The coefficient on change in house prices is about one third larger in locations with more available land, and the test of equality between the coefficients in columns (1a) and (1b) rejects with a p-value of 0.13. In addition, the constants suggest that steady-state construction is one-half as large in relatively developed regions. We would also note, however, that the estimated elasticities are much lower in this paper than other work that looks at longer time periods. (See Gyourko and Voith 2000, for example.)

B. Spending and Override Regression Results

In a next step we examine how the extent of capitalization, proxied by land availability, is related to spending changes during the 1990-1994 period. Our predictions are that communities with little available land, and thus a high extent of capitalization, spend more on public services than communities with plenty of developable land. At a first glance, the data seems to support our predictions. Table 5 reports descriptive statistics of certain characteristic variables for towns with more and less developable land. Before controlling for other factors that might affect demand for public services, towns with little available land are more likely to pass (an) override(s) and also spend more on schools and other public services than towns with more potentially developable land.

Table 6 reports estimates of the equations for percentage change in school spending and non-school spending between 1990 and 1994 in the 208 cities and towns with available data. The school spending regressions include the percent change in number of students between 1990-1994 as an endogenous variable, while the non-school spending regressions include the percent change in population between 1990-1994 as endogenous variable. Columns (1) and (2) report the equations with all of the variables described in the data section, a broad set of constraint variables from Proposition 2½, and the percentage of developed land.

Overall, several of the fiscal variables related to Proposition 2½ and education reform significantly affect spending changes in Massachusetts cities and towns. In the school spending equation (column 1) land availability has a positive effect on school spending that is statistically significant at the 5 percent level. The coefficient suggests that a decrease of 10 percent points of available land is associated with a 2.4 percent increase in education spending. Hence, the estimate confirms our theoretical prediction. All other coefficients but one (at levy limit, no overrides) have the anticipated sign and many variables are statistically different from zero.

Two other results are worth emphasizing. First, the coefficient of the change in the number of pupils is 0.70 and statistically different from both 1 and 0. This suggests that spending changes were responsive to the number of pupils, but less than one for one. Second, the results strongly confirm that Proposition 2½ indeed limited school spending. Cities and towns that were required to cut revenues for the first 2 or 3 years of Proposition 2½ (the communities that faced the largest initial constraints) increased their education spending by 9 and 16 percentage points less, respectively, than communities with zero or 1 year of initial revenue cuts.

The results for non-school spending are quite different compared to the ones for school spending. The coefficient of the land supply elasticity measure has a positive sign but is not statistically different from zero. Only two other constraint variables are individually statistically significant. Communities that had ever passed an override increased spending by 14 percentage points more than other communities. Furthermore, for every 1 percent that a community was required to increase school spending in 1994, non-school spending fell by 0.33 percent between 1990 and 1994. Finally, a 1 percent increase in population increases non-school spending by about 1.1 percent.

We have several potential explanations why the coefficient of the land supply elasticity measure may not be statistically different from zero in the non-school estimates. Non-school spending, dominated in most communities by fire and police services, may have fewer discretionary items than the school budget. Across all communities, the percentage change in non-school spending appears to be much “noisier” than the school spending data, suggesting that our measures of economic factors have a small effect on this portion of local budgets. We also conjecture that the marginal homebuyer may pay more attention to the school side of the budget if they are more likely to have children in school. In any case, BMC also find a similar pattern for school and non-school spending.

Columns (3) and (4) repeat the estimates in the first two columns without the potentially endogenous Proposition 2½ variables from the late 1980s. Overall, the coefficients of the remaining variables are quite similar. In particular the coefficients of the measure for land supply elasticity remain virtually unchanged.

The next question is how land availability affects the cumulative amount of overrides (per capita) passed in a community that is at its levy limit between 1990 and 1994. Rather than looking at spending in all communities, here we only examine communities that are constrained by Proposition 2½ and have bumped up against their state-mandated spending (levy) limits. Thus voters must approve increases in spending above 2½ percent per year in the form of an override. Similar to the spending regressions, we predict that land scarcity (and thereby the extent to which additional spending on schools is capitalized into house values) affects the incentives of homeowners to vote for an override.

Table 7 presents four different specifications of the amount of overrides approved by voters in communities that were at their levy limit in 1990. Column 1 reports results for the base equation that does not include Proposition 2½ variables. The regression only includes the percentage of developed land in 1984—our proxy for land supply elasticity—plus other local characteristics for 1990 that may affect demand for education. Notice that communities that are at their levy limit are already constrained by Proposition 2½ and there is no necessary reason that these variables should affect incremental spending above the Proposition 2½ limits. Nonetheless, Column (2) includes early 1980s Proposition 2½ variables. Column (3) then adds late 1980s Proposition 2½ variables. Finally, column (4) includes endogenous population changes in addition to the 1990 explanatory variables of the base regression.

The coefficient of the measure for land supply is positive and statistically significant at the 5 percent level (column 1) or at the 10 percent level (columns 2 to 4) in all four regressions. The size of the land supply coefficients is quite stable among all regressions. In addition to land supply, only a few other variables have a statistically significant effect on the cumulative amount of overrides. The ratio of enrollment to population has the anticipated positive sign and is statistically different from zero in all four regressions, suggesting communities with a higher percentage of residents in the public schools are more likely to support spending increases. This is not surprising given that the school side of the spending equation appears to be where most marginal spending cuts or increases are made. Along the same line, communities with a higher percentage of college educated adults are also more likely to approve higher overrides. Also of interest is that communities with a higher percentage of residents over age 65 are more likely to support overrides, which is in contrast to the common perception that elderly voters do not support many spending increases. One potential explanation for this phenomenon is that older residents may take into account the utilities of their children and grandchildren, and possibly, more generally the utilities of children or future generations in their community. An alternative explanation may be that older residents have strong preferences for certain types of durable local public goods such as parks or services to the elderly, which were possible recipients of additional spending.

Finally, we confirm that land availability has a limited impact on the probability that a community in Massachusetts is at its levy limit. One might be concerned that land availability is correlated with the likelihood of being at the levy limit, possibly through its impact on past spending decisions prior to 1990. This might explain why communities with little available land typically are more likely to support an override. We present binary logit estimates of the probability that a town is at its levy limit and include the percentage of developed land in 1984 as explanatory variable. Table 8 reports results for two specifications. The basic estimating equation reported in column (1) includes several local characteristics for 1990 that are expected to affect the probability that a community is at its levy limit. We also include the percentage of developed land. The estimating equation reported in column (2) additionally includes the early 1980s Proposition 2½ variables. The coefficient for the percentage of developed land in 1984 is positive, but small, and is not statistically different from zero. Hence, the binary logit estimates confirm our prediction.

4 Conclusion

In this paper we present theoretical propositions and supporting empirical work that shows that the extent of capitalization depends critically on the supply of available land within a metropolitan area. In particular, we argue that capitalization of fiscal variables and amenities should be especially high in urban areas where there is little available land and capitalization should be quite low in rural locations where land is more readily available. We also argue that localities with little available land should spend more on local public goods such as schools. The extent to which voters may benefit from spending increases despite the levy limit depends on the degree of capitalization of these benefits into house values. Hence, the degree of capitalization is expected to affect individual incentives and voting behavior.

We examine these theoretical predictions using a unique data set from Massachusetts that includes a measure of available land for a large number of communities. Consistent with the theory, we find that fiscal variables and amenities are capitalized to a much greater extent in towns with little available land, and confirm that these locations have a lower elasticity of land supply. We then show that these communities also spend more on schools and voters in these cities and towns are more likely to pass overrides in order to undertake costly spending programs. Hence, our finding might explain why rural communities and locations at the edge of cities spend less on local public goods such as schools than more densely populated suburban areas with little available land. Furthermore, our empirical findings question the validity of theoretical models (e.g., Epple et al., 1984 and 1993) that assume myopic voters who do not take into account the effect of their votes on the housing stock.

While our theoretical framework makes no distinction between renting and owning a home, our findings have implications for government policies that redistribute income based on location. Free mobility implies that any governmental measure—such as federal grants or state aid—targeted at one location can impact house prices across a metropolitan area. Our findings suggest that capitalization of government grants mainly benefits owners of real estate in urban areas. To the extent that homeowners are wealthier than renters, adverse redistribution effects caused by capitalization should be stronger in urban areas than in rural areas or locations at the edge of cities.

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Appendix

A. Model with Mobile Households

Consider a framework with two communities (or one specific community and the rest of the metropolis) and *N* residents who are perfectly mobile and have identical incomes and tastes. Residents in both communities *j=1,2* choose housing quantity to maximize utility, taking the level of public service, g_j, and the property tax rate, τ_j, as given. Let $V(y, p_j(1+\tau_j), g_j)$ denote the indirect utility function, where y, p_j are the household income and the price of housing per unit in the *j*th community.

Equilibrium Conditions

Equilibrium requires that households have equal utility in both communities. The first equilibrium condition can thus be expressed as

$$V(y, p_1(1+\tau_1), g_1) - V(y, p_2(1+\tau_2), g_2) = 0. \qquad \text{(A1)}$$

In addition, all *N* residents must live in either of the two communities, that is,

$$n_1 + n_2 = N, \qquad \text{(A2)}$$

where n_j is the population of community *j*. The last equilibrium condition requires that housing demand equals housing supply in both communities,

$$n_j h_j(p_j(1+\tau_j)) = H(p_j), \qquad \text{(A3)}$$

where h_j is the demand of housing per resident and $H(p_j)$ is the housing supply function. We use housing supply to simplify the analysis. However, the results are analogous to the case with an elastic supply of land. Using (A3) in (A2) we obtain:

$$\frac{H_1(p_1)}{h_1(p_1(1+\tau_i))} + \frac{H_2(p_2)}{h_2(p_2(1+\tau_i))} = N. \qquad \text{(A4)}$$

The equations (A1) and (A4) are the equilibrium conditions that determine p_1 and p_2. Differentiating these two equations with respect to g_1, we obtain:

$$\begin{bmatrix} -(1+\tau_1)h_1 & (1+\tau_2)h_2 \\ \frac{n_1}{p_1}\left(\varepsilon_1^S-\varepsilon_1^D\right) & \frac{n_2}{p_2}\left(\varepsilon_2^S-\varepsilon_2^D\right) \end{bmatrix} \begin{bmatrix} \partial p_1/\partial g_1 \\ \partial p_2/\partial g_1 \end{bmatrix} = \begin{bmatrix} -MRS_1 \\ 0 \end{bmatrix}, \tag{A5}$$

where $\varepsilon_j^S = \frac{\partial H_j}{\partial p_j}\frac{\partial p_j}{\partial H_j}$ is the price elasticity of housing supply, and $\varepsilon_j^D = \frac{\partial h_j}{\partial p_j}\frac{\partial p_j}{\partial h_j}$ is the price elasticity of housing demand and where $MRS_j = \frac{\partial V/\partial g_j}{\partial V/\partial y}$. We get equation (A5) by using Roy's identity to replace $\frac{\partial V}{\partial p_j}$ with $-\frac{\partial V}{\partial y}\cdot h_j(p_j(1+\tau_j))$ and by assuming that $\frac{\partial V_1}{\partial y}=\frac{\partial V_2}{\partial y}$.

Differentiating (A1) and (A4) with respect to g_2 we obtain:

$$\begin{bmatrix} -(1+\tau_1)h_1 & (1+\tau_2)h_2 \\ \frac{n_1}{p_1}\left(\varepsilon_1^S-\varepsilon_1^D\right) & \frac{n_2}{p_2}\left(\varepsilon_2^S-\varepsilon_2^D\right) \end{bmatrix} \begin{bmatrix} \partial p_1/\partial g_2 \\ \partial p_2/\partial g_2 \end{bmatrix} = \begin{bmatrix} MRS_2 \\ 0 \end{bmatrix}. \tag{A6}$$

Adding taxes, we obtain the following sets of equations:

$$\begin{bmatrix} -(1+\tau_1)h_1 & (1+\tau_2)h_2 \\ \frac{n_1}{p_1}\left(\varepsilon_1^S-\varepsilon_1^D\right) & \frac{n_2}{p_2}\left(\varepsilon_2^S-\varepsilon_2^D\right) \end{bmatrix} \begin{bmatrix} \partial p_1/\partial \tau_1 \\ \partial p_2/\partial \tau_1 \end{bmatrix} = \begin{bmatrix} p_1 h_1 \\ \frac{n_1}{\left(1+\tau_1\right)}\varepsilon_1^D \end{bmatrix} \tag{A7}$$

$$\begin{bmatrix} -(1+\tau_1)h_1 & (1+\tau_2)h_2 \\ \frac{n_1}{p_1}\left(\varepsilon_1^S-\varepsilon_1^D\right) & \frac{n_2}{p_2}\left(\varepsilon_2^S-\varepsilon_2^D\right) \end{bmatrix} \begin{bmatrix} \partial p_1/\partial \tau_2 \\ \partial p_2/\partial \tau_2 \end{bmatrix} = \begin{bmatrix} -p_2 h_2 \\ \frac{n_2}{\left(1+\tau_2\right)}\varepsilon_2^D \end{bmatrix}. \tag{A8}$$

Comparative Static Results

Solving (A5)-(A8) we get the following comparative static results:

$$\frac{\partial p_1}{\partial g_1} = \frac{-MRS_1 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right)}{|A|} \tag{A9}$$

$$\frac{\partial p_2}{\partial g_1} = \frac{MRS_1 \frac{n_1}{p_1}\left(\varepsilon_1^S - \varepsilon_1^D\right)}{|A|} \tag{A10}$$

$$\frac{\partial p_1}{\partial g_2} = \frac{MRS_2 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right)}{|A|} \tag{A11}$$

$$\frac{\partial p_2}{\partial g_2} = \frac{-MRS_2 \frac{n_1}{p_1}\left(\varepsilon_1^S - \varepsilon_1^D\right)}{|A|} \tag{A12}$$

$$\frac{\partial p_1}{\partial \tau_1} = \frac{p_1 h_1 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right) - \frac{n_1}{(1+\tau_1)}\varepsilon_1^D (1+\tau_2) h_2}{|A|} \tag{A13}$$

$$\frac{\partial p_2}{\partial \tau_1} = \frac{-p_1 h_1 \frac{n_1}{p_1}\left(\varepsilon_1^S - \varepsilon_1^D\right) - \frac{n_1}{(1+\tau_1)}\varepsilon_1^D (1+\tau_1) h_1}{|A|} \tag{A14}$$

$$\frac{\partial p_1}{\partial \tau_2} = \frac{-p_2 h_2 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right) - \frac{n_2}{(1+\tau_2)}\varepsilon_2^D (1+\tau_2) h_2}{|A|} \tag{A15}$$

$$\frac{\partial p_2}{\partial \tau_2} = \frac{-p_2 h_2 \frac{n_1}{p_1}\left(\varepsilon_1^S - \varepsilon_1^D\right) - \frac{n_2}{(1+\tau_2)}\varepsilon_2^D (1+\tau_1) h_1}{|A|} \tag{A16}$$

where $|A| = -(1+\tau_1) h_1 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right) - (1+\tau_2) h_2 \frac{n_1}{p_1}\left(\varepsilon_1^S - \varepsilon_1^D\right)$.

These comparative statics give us some important insights. The extent of capitalization depends on the elasticity of housing supply. However, the elasticity of housing supply in one community affects the extent of capitalization in the other community. In fact, it can be shown that

$$\frac{\partial^2 p_1}{\partial g_1 \partial \varepsilon_1^S} < 0 . \tag{A17}$$

That is, the extent of capitalization of an exogenous fiscal shock in community 1 decreases with increasing housing supply elasticity in community 1 (see Appendix B for a proof of this result). However, the extent of capitalization of an exogenous fiscal shock in community 2 increases with increasing housing supply elasticity in community 1 as is shown in equation (A18):

$$\frac{\partial^2 p_2}{\partial g_2 \partial \varepsilon_1^S} < 0 . \tag{A18}$$

Furthermore, the impact of the elasticity of supply on capitalization depends on the population share of the community. From the comparative static results (A9) and (A14) it can be easily derived that if a community has a sufficiently small share of the population, that is as $n_1 \rightarrow 0$ and $n_2 \rightarrow N$, the elasticity of its supply does not affect the capitalization rate.

B. Proof of Main Proposition

This appendix derives our main proposition (equation A17 in Appendix A) that the land supply elasticity negatively affects the extent of capitalization. To begin with, consider equation (A9) from Appendix A:

$$\frac{\partial p_1}{\partial g_1} = \frac{-MRS_1 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right)}{|A|}, \tag{A9}$$

where $|A| = -\left(1+\tau_1\right) h_1 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right) - \left(1+\tau_2\right) h_2 \frac{n_1}{p_1}\left(\varepsilon_1^S - \varepsilon_1^D\right)$.

We can use the quotient rule to differentiate (A9) with respect to ε_1^S :

$$\frac{\partial^2 p_1}{\partial g_1 \partial \varepsilon_1^S} = \frac{0 \cdot |A| - \left(-MRS_1 \frac{n_2}{p_2}\left(\varepsilon_2^S - \varepsilon_2^D\right)\right) \cdot \left(-\left(1+\tau_2\right) h_2 \frac{n_1}{p_1}\right)}{|A|^2} \tag{B1}$$

The denominator of (B1) must be > 0. Assuming that the marginal utility of the publicly provided service and the numeraire good are both positive, it follows that $MRS_1 > 0$. We also assume that $\left(\varepsilon_2^S - \varepsilon_2^D\right)$, housing consumption, population sizes and prices are > 0. Hence, the nominator of (B1) is always < 0 and therefore $\frac{\partial^2 p_1}{\partial g_1 \partial \varepsilon_1^S} < 0$.

C. Summary Statistics and Regression Tables

Table 1
Variable List and Means
N=208

Variable	Mean	Standard Deviation	Minimum	Maximum
Endogenous Variables:				
Percent change in house prices, FY1990-94	-0.077	0.057	-0.208	0.071
Percent change in school spending, FY1990-94	0.15	0.09	-0.15	0.54
Percent change in non-school spending, FY1990-94	0.083	0.158	-0.323	0.680
Single family permits, 1990-94, per 1990 housing unit	0.046	0.038	0.001	0.230
Fiscal Variables:				
Effective property tax rate, FY1980	0.031	0.009	0.012	0.086
Dummy, one year of initial levy reductions, FY1982	0.46	0.50	0	1
Dummy, two years of initial levy reductions, FY1982-83	0.12	0.32	0	1
Dummy, three years of initial levy reductions, FY1982-84	0.034	0.181	0	1
Excess capacity as percentage of levy limit, FY1989	0.018	0.036	0.000	0.200
Dummy variable, at levy limit and no overrides, FY1989*	0.44	0.50	0	1
Dummy variable, passed override(s) prior to FY1990	0.11	0.31	0	1
Dummy variable, "unconstrained" in FY1989*	0.46	0.50	0	1
Equalized property value per capita, 1980 (000)	16.4	6.2	6.3	44.1
Nonresidential share of property value, FY1980	0.19	0.09	0.04	0.60
Percentage of revenue from state aid, FY1984	0.26	0.10	0.05	0.52
Percentage of revenue from state aid, FY1981	0.19	0.08	0.05	0.43
Percentage increase in state aid, FY1981-84	0.43	0.31	-0.44	3.38
Community Characteristics:				
School test scores, 1990*	2690	168	2160	3080
Fraction of 1980 population under age 5	0.062	0.013	0.032	0.112
Dummy variable, in Boston metro area (PMSA)	0.45	0.50	0	1
Dummy variable, in Boston suburban ring*	0.19	0.40	0	1
Developable land per housing unit, 1984*	0.66	0.41	0.04	2.17
Single family permits per 1990 housing unit, 1989	0.008	0.007	0.000	0.038
Enrollment/population ratio, 1981	0.20	0.04	0.08	0.42
Median family income, 1980 (000)	21.0	5.6	11.5	47.6
Dummy variable, member of regional district	0.26	0.44	0	1
Dummy variable, member of regional high school	0.19	0.39	0	1
Percent of adult residents with college education, 1980	0.20	0.12	0.05	0.60

Notes, marked with asterisks:
"At levy limit" is defined as levy within 0.1 percent of levy limit.
"Unconstrained" communities are not at levy limit in FY1989 and have passed no overrides prior to FY1990.
School test scores is combined math and reading MEAP test score for 8th graders in 1990.
Boston suburban ring is defined as within MSA but outside PMSA.
Developable land is defined as open, non-public acres plus land in residential use.
Sources: Massachusetts Department of Education; Massachusetts Department of Revenue, Division of Local Services, Municipal Data Bank; U.S. Department of Commerce, Bureau of the Census.

Table 2
House Price Regression Results Using Land Scarcity as Proxy for Land Supply Elasticity
Dependent Variable: Percent Change in House Prices, Fiscal Years 1990-1994
Sample divided by percentage of open and public (undeveloped) land in each community

Specification	Base set of instruments		Base set of instruments plus Proposition 2½ variables from late 1980s	
Explanatory Variable	Less Developable Land (1a)	More Developable Land (1b)	Less Developable Land (2a)	More Developable Land (2b)
Single family permits, 1990-1994, per 1990 housing units	-.64 ** (.20)	-.14 (.17)	-.49 ** (.15)	-.087 (.15)
Percent change in school spending, FY 1990-94	.32 ** (.12)	.12 (.11)	.24 ** (.088)	.13 (.087)
Percent change in non-school spending, FY 1990-94	.064 (.089)	.038 (.061)	.033 (.051)	-.021 (.038)
Combined math and reading MEAP test score, 8th grade students, 1990 (x 10^3)	.14 ** (.028)	.11 ** (.032)	.14 ** (.026)	.12 ** (.026)
Dummy variable, in Boston metro area	.097 ** (.013)	.075 ** (.011)	.095 ** (.011)	.076 ** (.011)
Dummy variable, in Boston suburban ring	.11 ** (.022)	.036 ** (.0094)	.10 ** (.019)	.036 ** (.0089)
Constant	-.55 ** (.078)	-.42 ** (.081)	-.54 ** (.069)	-.46 ** (.068)
Number of observations	104	104	104	104

Numbers in parentheses are robust standard errors.
* Significantly different from zero with 90 percent confidence.
** Significantly different from zero with 95 percent confidence.
Notes: **Bold** variables are endogenous. Instruments in column (1a) and (1b) include effective tax rate in 1980, dummy variables for the number of years required to reduce spending due to Proposition 2½, 1980 levels of resource variables from Table 1 (equalized property value per capita), non residential share of property value, median family income, and percentage of adults with a college degree), percentage increase in state aid 1981-84, percentage of revenue from state aid in 1984, and dummies for regional school district or high school. Instruments in column (2a) and (2b) include those from column (1a) and (1b) plus 1989 constraint variables (excess capacity as a percentage of the levy limit, dummy indicating the community is at its levy limit, and a dummy indicating the community had previously passed an override) and the increase in education spending from 1993-94 required by the education reform bill.

Table 3
House Price Regression Results Using Density as Proxy for Land Supply Elasticity
Dependent Variable: Percent Change in House Prices, Fiscal Years 1990-1994
Sample divided by population density in each community

Specification	Base set of instruments		Base set of instruments plus Proposition 2½ variables from late 1980s	
Explanatory Variable	More Densely Populated (1a)	Less Densely Populated (1b)	More Densely Populated (2a)	Less Densely Populated (2b)
Single family permits, 1990-94, per 1990 housing units	.027 (.25)	-.27 (.18)	.013 (.22)	-.11 (.13)
Percent change in school spending, FY 1990-94	.26 * (.15)	.14 * (.083)	.12 (.10)	.15 ** (.073)
Percent change in non-school spending, FY 1990-94	-.076 (.085)	.042 (.054)	.026 (.050)	-.038 (.041)
Combined math and reading MEAP test score, 8th grade students, 1990 (x 10^3)	. 18 ** (.028)	.069 ** (.030)	. 16 ** (.023)	.081 ** (.030)
Dummy variable, in Boston metro area	.10 ** (.014)	.072 ** (.0092)	.086 ** (.011)	.073 ** (.0092)
Dummy variable, in Boston suburban ring	.059 ** (.012)	.058 ** (.013)	.056 ** (.011)	.057 ** (.011)
Constant	-.64 ** (.078)	-.32 ** (.082)	-.57 ** (.060)	-.36 ** (.082)
Number of observations	104	104	104	104

Numbers in parentheses are robust standard errors.
* Significantly different from zero with 90 percent confidence.
** Significantly different from zero with 95 percent confidence.
Notes: **Bold** variables are endogenous. Instruments in column (1a) and (1b) include effective tax rate in 1980, dummy variables for the number of years required to reduce spending due to Proposition 2½, 1980 levels of resource variables from Table 1 (equalized property value per capita), non residential share of property value, median family income, and percentage of adults with a college degree), percentage increase in state aid 1981-84, percentage of revenue from state aid in 1984, and dummies for regional school district or high school. Instruments in column (2a) and (2b) include those from column (1a) and (1b) plus 1989 constraint variables (excess capacity as a percentage of the levy limit, dummy indicating the community is at its levy limit, and a dummy indicating the community had previously passed an override) and the increase in education spending from 1993-94 required by the education reform bill.

Table 4
Land Supply Elasticity Regression Results
Dependent Variable: Single family permits, 1990-1994, per 1990 housing units
Sample divided by percentage of open and public (undeveloped) land in each community

Specification	Base set of instruments (without lagged supply as exogenous variable)		Base set of instruments (with lagged supply as exogenous variable)	
Explanatory Variable	Less Developable Land (1a)	More Developable Land (1b)	Less Developable Land (2a)	More Developable Land (2b)
Percentage change in house prices, 1990-1994	.0070 (.056)	.15 * (.080)	.13 ** (.038)	.18 ** (.047)
Single family permits, 1989, per 1989 housing units			4.9 ** (.44)	3.6 ** (.43)
Constant	.043 ** (.0055)	.064 ** (.0086)	.016 ** (.0049)	.032 ** (.0062)
Number of observations	104	104	104	104

Numbers in parentheses are robust standard errors.
* Significantly different from zero with 90 percent confidence.
** Significantly different from zero with 95 percent confidence.
Notes: **Bold** variable is endogenous. The instruments are all of the exogenous variables in the demand equation in table 2 plus the exogenous instruments from the demand equation of columns (1a) and (1b) in table 2.

Table 5
Descriptive Statistics of Characteristic Variables for Towns with More and Less Developable Land
N_1=104, N_2=104

Variable	Mean	Std. Dev.	Min.	Max.
Towns with More Developable Land (N_1=104 Observations):				
Percent change in school spending, FY1990-94	.141	.0852	-.151	.315
Percent change in non-school spending, FY1990-94	.0656	.156	-.319	.564
Dummy, community passed override(s) between FY 1990-94	.346	.478	0	1
Dummy, town is at its levy limit in 1990 ("constrained")	.721	.451	0	1
Median family income, 1990 (in '000)	42.2	11.4	22.6	93.9
Percent change in house prices, FY1990-94	-.0859	.0517	-.192	.0258
Towns with Less Developable Land (N_2=104 Observations):				
Percent change in school spending, FY1990-94	.150	.0871	-.102	.544
Percent change in non-school spending, FY1990-94	.100	.158	-.323	.680
Dummy, community passed override(s) between FY 1990-94	.567	.498	0	1
Dummy, town is at its levy limit in 1990	.769	. 423	0	1
Median family income, 1990 (in '000)	46.8	13.7	22.1	95.1
Percent change in house prices, FY1990-94	-.0675	.0607	-.208	.0709

Notes, marked with asterisks:
Education reform law's school spending rise is FY1993-94 required percentage increase in education spending.
"At levy limit" is defined as levy within 0.1 percent of levy limit.
"Constrained" communities are at levy limit in FY1990 and have passed no overrides prior to FY1990.
Developable land is defined as open, non-public acres plus land in residential use.
Sources: Massachusetts Department of Education; Massachusetts Department of Revenue, Division of Local Services, Municipal Data Bank; U.S. Department of Commerce, Bureau of the Census.

Table 6
Spending Regression Results
Dependent Variable: Percent Change in School or Non-school Spending, Fiscal Years 1990-94

Explanatory Variable	School Spending (1)	Non-school Spending (2)	School Spending (3)	Non-school Spending (4)
Percent change in number of students, 1990-94	.70 **		.75 **	
	(.16)		(.16)	
Percent change in population, 1990-94		1.12 *		1.07 *
		(.62)		(.62)
Percentage of Developed Land in 1984	.24 **	.24	.25 **	.29
	(.12)	(.18)	(.12)	(.20)
Equalized property value per capita, FY1990 ($x10^9$)	.74	.45	.82	.10
	(.50)	(.74)	(.56)	(.75)
Ratio, enrollment to population, FY1990	.55 **	-.39	.69 **	-.20
	(.28)	(.44)	(.28)	(.45)
Median family income, 1990	-.0028 **	-.00015	-.0033 **	-.00010
	(.0011)	(.0020)	(.0013)	(.0020)
Percentage of revenue from state aid, FY1984	.25 **	.014	.26 **	-.13
	(.10)	(.22)	(.099)	(.20)
Nonresidential share of property value, FY1990	.011	-.017	-.026	-.057
	(.074)	(.12)	(.079)	(.13)
Dummy variable, member of regional school district	.052 *	-.027	.053 **	-.058
	(.027)	(.073)	(.026)	(.066)
Dummy variable, member of regional high school	-.017	-.013	-.021	.026
	(.025)	(.069)	(.025)	(.064)
Percentage increase in state aid, FY1981-84	-.0093	.033	-.00021	.055 *
	(.015)	(.029)	(.013)	(.030)
Percent of adult residents with college education, 1990	.17 *	-.14	.18 *	-.058
	(.096)	(.17)	(.10)	(.20)
Effective property tax rate, FY1980	1.7	-1.4	2.4 **	-.32
	(1.1)	(2.1)	(1.1)	(2.0)
Dummy variable, required one year of initial levy reductions, FY1982	-.013	.023	-.021	.012
	(.014)	(.030)	(.014)	(.031)
Dummy variable, required two years of initial levy reductions, FY1982-83	-.086 **	-.016	-.094 **	-.013
	(.027)	(.047)	(.029)	(.047)
Dummy variable, required three years of initial levy reductions, FY1982-84	-.16 **	.051	-.17 **	.042
	(.050)	(.072)	(.049)	(.073)
Excess spending per pupil (required>actual spending), FY1994	.015	-.33 **		
	(.081)	(.17)		
Excess capacity as a percentage of levy limit, FY1989	.44	-.12		
	(.29)	(.32)		
Dummy variable, at levy limit and no overrides, FY1989	.044 **	.044		
	(.017)	(.027)		
Dummy variable, passed override(s) prior to FY1990	.059 **	.14 **		
	(.019)	(.034)		
Constant	-.31 **	-.048	-.31 **	-.18
	(.13)	(.20)	(.13)	(.21)
Adjusted R-squared	.17	.23	.090	.12
Number of observations	208	208	208	208

Numbers in parentheses are standard errors. *Significantly different from zero with 90 percent confidence. **Significantly different from zero with 95 percent confidence.
Notes: **Bold** variables are endogenous. Spending equations (1) and (2) include fiscal variables from the early 1980s, Proposition 2½ variables from 1989, and the excess spending per pupil in 1994 (required>actual spending). Spending equations (3) and (4) include fiscal variables from 1990 and early Proposition 2½ variables. Instruments include the single family permits in 1989 per 1990 housing units, the fraction of a community's population under age 5, developable land in 1984, housing permits in 1989, dummy variables for inside the Boston PMSA and suburban ring, fraction of residents in manufacturing in 1990, fraction of the population aged 35-60 in 1990, and average eighth grade reading and math test score in 1990.

Table 7
Override Regression Results Including Percentage of Developed Land As Independent Variable
Dependent Variable: Cumulative Amount of Overrides Passed in a Community per Capita, FY 1990-1994

Explanatory Variable	OLS Base Equation (1)	OLS Base Equation Plus Early 80s Prop. 2 ½ Var. (2)	OLS Base Equation Plus Late 80s Prop. 2 ½ Var. (2)	2SLS Endogenous Population Change (4)
Percent change in population, 1990-94				-296.3 **
				(144.0)
Percentage of Developed Land in 1984	92.7 **	96.0 *	93.1 *	76.8 *
	(46.0)	(51.7)	(52.9)	(46.0)
Equalized property value per capita, FY1990 (x10^6)	.10	.089	.049	.29
	(.28)	(.29)	(.28)	(.27)
Ratio, enrollment to population, FY1990	305.9 **	283.8 **	244.1 **	288.6 **
	(111.5)	(114.4)	(105.2)	(112.6)
Median family income, 1990	.14	.16	.30	.43
	(.78)	(.80)	(.79)	(.79)
Nonresidential share of property value, FY1990	-76.0 **	-66.5 *	-51.8	-105.9 **
	(38.2)	(40.2)	(41.2)	(38.5)
Dummy variable, member of regional school district	2.9	.91	-.66	10.5
	(17.8)	(18.6)	(15.9)	(18.4)
Dummy variable, member of regional high school	14.6	15.9	16.2	11.0
	(18.1)	(18.6)	(17.1)	(18.1)
Percent of adult residents with college education, 1990	149.6 **	149.1 **	141.7 **	101.1
	(69.5)	(69.0)	(70.9)	(72.2)
Percent of residents with age over 65	294.2 **	270.1 **	296.3 **	114.0
	(128.1)	(131.7)	(136.3)	(142.1)
Effective property tax rate, FY1980		-136.6	-36.2	
		(570.2)	(570.4)	
Dummy variable, required one year of initial levy reductions, FY1982		-6.2 (7.9)	-5.0 (8.6)	
Dummy variable, required two years of initial levy reductions, FY1982-83		4.2 (14.2)	-.61 (14.7)	
Dummy variable, required three years of initial levy reductions, FY1982-84		-1.8 (18.6)	-6.1 (19.1)	
Excess spending per pupil (required>actual spending), FY1994			24.1 (32.4)	
Excess capacity as a percentage of levy limit, FY1989			-62.3	
			(259.6)	
Dummy variable, at levy limit and no overrides, FY1989			1.5 (7.9)	
Dummy variable, passed override(s) prior to FY1990			27.3 **	
			(13.1)	
Constant	-179.4**	-170.6**	-178.2 **	-142.2 **
	(54.3)	(59.3)	(58.4)	(54.6)
Adjusted R-squared	.44	.44	.47	.45
Number of observations	155	155	155	155

Numbers in parentheses are standard errors.
*Significantly different from zero with 90 percent confidence.
**Significantly different from zero with 95 percent confidence.
Note: **Bold** variable is endogenous. Regressions include only communities that are at their levy limit. Equation (1) is base equation. Equation (2) additionally includes early 1980s Proposition 2½ variables. Equation (3) additionally includes late 1980s Proposition 2½ variables. Equation (4) includes endogenous population changes. Instruments include the single family permits in 1989 per 1990 housing units, the fraction of a community's population under age 5, developable land in 1984, housing permits in 1989, dummy variables for inside the Boston PMSA and suburban ring, fraction of residents in manufacturing in 1990, fraction of the population aged 35-59 in 1990, and average eighth grade reading and math test score in 1990.

Table 8
Logit Estimates of Probability That a Town Is At Its Levy Limit
Dependent Variable: Dummy variable, at levy limit in FY 1990

Explanatory Variable	Base equation (1)	Base Equation Plus Early 1980s Proposition 2½ Variables (2)
Percentage of Developed Land in 1984	4.3 (3.2)	3.4 (3.2)
Equalized property value per capita, FY1990 ($x10^6$)	-.025 ** (.011)	-.018 (.012)
Ratio, enrollment to population, FY1990	19.6 ** (7.5)	23.4 ** (7.8)
Median family income, 1990	.036 (.032)	.044 (.033)
Nonresidential share of property value, FY1990	-.43 (2.1)	-1.4 (2.1)
Dummy variable, member of regional school district	-2.0 ** (.68)	-1.5 ** (.72)
Dummy variable, member of regional high school	1.4 ** (.72)	1.13 (.76)
Percent of adult residents with college education, 1990	1.3 (2.6)	-.32 (2.8)
Percent of residents with age over 65	2.0 (6.7)	3.9 (6.4)
Effective property tax rate, FY1980		78.0 ** (37.3)
Dummy variable, required one year of initial levy reductions, FY1982		-.36 (.48)
Dummy variable, required two years of initial levy reductions, FY1982-83		-.66 (.82)
Dummy variable, required three years of initial levy reductions, FY1982-84		-.95 (1.6)
Constant	-5.6 * (3.2)	-8.0 ** (3.4)
Adjusted R-squared	-107.0	-104.3
Number of observations	208	208

Numbers in parentheses are standard errors.
*Significantly different from zero with 90 percent confidence.
**Significantly different from zero with 95 percent confidence.
Note: Equation (1) is base equation. Equation (2) additionally includes early 1980s Proposition 2½ variables.